NEW LIGHT ON ISOSTASY.

FACILITIES for the measurement of gravity by means of the pendulum have been greatly improved in recent years. The apparatus devised by Dr. Mendenhall for the Coast Survey not only affords results of high precision but enables an observer traveling from point to point to make at least one measurement each week. During five months of 1894 Mr. G. R. Putnam, of that survey, occupied twenty-six stations, a greater number than has previously been successfully occupied in North America. The measurements have the further advantage that they are homogeneous, being all made by the same observer with the same apparatus; and as it is understood that the work is to be continued, American geologists and geodesists may confidently look forward to such a knowledge of the distribution of mass in the continent as will materially clarify conceptions of the inner earth.

A brief report of Mr. Putnam's results was communicated by Dr. Mendenhall to the National Academy of Science, and printed in the *American Journal of Science* for January. A fuller account of the work and a discussion of the results were presented to the Philosophical Society of Washington by Mr. Putnam, and have recently appeared in the Bulletin of the Society. Under the same cover also are comments by the present writer.[1] While these discussions are merely tentative, and were undertaken primarily for the purpose of indicating the most advantageous directions for future work by the Coast Survey, certain of the inferences drawn are of such importance and so little liable to be overthrown that their presentation to the readers of the JOURNAL seems warranted.

[1] Results of a Transcontinental Series of Gravity Measurements, by GEORGE ROCKWELL PUTNAM; and Notes on the Gravity Determinations reported by Mr. G. R. Putnam, by GROVE KARL GILBERT. Bull. Phil. Soc. Wash. Vol. XIII., pp. 31–75.

The majority of the stations are arranged in a chain from the eastern coast to Salt Lake City. Two stations are on the Pacific Coast and three in Yellowstone Park. In discussing the measurements, I have started with the general postulate that continents and ocean beds are in isostatic equilibrium, and have sought to determine from the local values of gravity the extent to which various geological provinces of the country deviate from perfect isostatic adjustment. Between the Appalachian and Rocky Mountains is a great plain, which has been exempt for a succession of geologic periods from orogenic disturbances, and during that time has had exceptional opportunity for the gradual relief, through viscous flow, degradation and sedimentation, of the strains engendered by gravity in connection with anomalies of density. It seems, therefore, *a priori* probable that this plain is in approximate equilibrium; and, if so, the average attraction on the plain may advantageously be used as a standard of reference in the consideration of other provinces. Eleven of the stations belong to the plain and they are well spaced from east to west. An examination shows the values of gravity at these stations to be notably accordant. When the mean of the eleven measurements is subtracted from the several measurements, the average residual is found to be only $\frac{1}{120000}$ of g, or such a differential acceleration as would be caused by the addition or subtraction of a layer of rock 240 feet thick.

Referring all the measurements to the standard thus obtained, it is found that there is an excess of attraction in all the mountain districts where measurements were made. In the Rocky Mountains of Colorado there are two stations, at Pike's Peak and Gunnison, and the excess of gravity determined at these stations is equivalent to the attraction of a rock layer 2200 feet thick. That is to say, if this mountain belt, 150 miles broad, were pared away to an average depth of 2200 feet, the local gravitation would then correspond to that on the interior plain. Now it also appears, as a generalization from the Hayden contour map of Colorado, that if this same district were leveled by removing the mountain tops and using the material to fill the valleys, it would

be converted into a plateau between 2000 and 2500 feet higher than the adjacent portion of the plain. The conclusion is thus reached that the whole mountain mass above the level of its base is in excess of the requirement for isostatic adjustment; or, in other words, is sustained by the rigidity of the earth. Three stations in Yellowstone Park tell the same story as to the Rocky Mountains of Montana, and single stations on the Wasatch Plateau and the Appalachian Mountains indicate that those uplands are rigidly upheld.

These results tend to show that the earth is able to bear on its surface greater loads than American geologists, myself included, have been disposed to admit. They indicate that unloading and loading through degradation and deposition cannot be the cause of the continued rising of mountain ridges with reference to adjacent valleys, but that, on the contrary, the rising of mountain ridges, or orogenic corrugation, is directly opposed by gravity and is accomplished by independent forces in spite of gravitational resistance.

While the new data thus indicate that the law of isostasy does not obtain in the case of single ridges of the size of a large mountain range, they agree with all other systems of gravity measurements in declaring the isostasy of the greater features of relief. The mode of reducing gravity measurements at different places so as to make them comparable depends on the theoretic conception of terrestrial rigidity, one method being followed when high rigidity is postulated and another when isostasy is postulated. Under the postulate of high rigidity it is assumed that all parts of the crust have the same density; under the postulate of isostasy each vertical element of the crust is assumed to have the same mass, density being inversely related to altitude of the surface. If either of these postulates were absolutely true the measurements, when reduced in accordance with it, would become identical, except for errors of observation; and approximation to such identity is a measure of the degree of approximation of the corresponding postulate to the actual fact. Mr. Putnam and the writer independently applied

this test by reducing series of measurements under each of the two postulates, and our conclusions are of the same tenor. Treating fourteen measurements, he found the results obtained under the postulate of rigidity fifteen times as discordant as the results under the postulate of isostasy; treating twenty-six measurements, I found the ratio as six to one. These measurements pertain to stations distributed among the plateaus that make up the continent, plateaus ranging in general attitude from 100 feet to 8700 feet; and the comparison shows that these plateaus are approximately in isostatic equilibrium.

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